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Six hundred and fifty-fourth Meeting.

February 11, 1873. — ADJOURNED STATED MEETING.

The PRESIDENT in the chair.

Professor William Watson was appointed Recording Secretary *pro tem.*

The Corresponding Secretary read a communication from Professor E. P. Seaver, acknowledging his election into the Academy.

He also gave notice that seventy copies of the Life and Works of Count Rumford had been distributed to Foreign Honorary Members and other men of science in Europe.

The Committee to whom the amendment of the Statutes was referred made the following report.

It is recommended to the Academy to substitute for the first four lines of Section 2 in Chapter IX. of the Statutes the following, viz.: —

Candidates for election as Resident Fellows must be proposed by two or more Resident Fellows in a recommendation signed by them, specifying the section for which they are proposed; which recommendation shall be read at a meeting and thereupon referred to the Council for nomination. No person recommended shall be reported by the Council as a candidate for election unless he shall have received a written approval authorized and signed, at a meeting of the Council, by at least seven of its members, to be reported to the Academy at a stated meeting. No ballot shall be held on a nomination by the Council until the stated meeting next after such nomination has been reported to the Academy.

It was moved by Mr. Edmund Quincy that the report be accepted and placed on file, in order that the amendment might be acted upon after the proper interval.

The Academy elected Wilhelm Hofmeister, of Heidelberg, a Foreign Honorary Member in Class II., Section 2 (Botany), in place of the late Hugo von Mohl, of Tübingen.

On the motion of Mr. Quincy, the hall of the Academy was tendered to the Massachusetts Historical Society for Thursday next, and for such other times as may suit their convenience.

Professor J. M. Crafts read a paper on "The Volumetric Analysis of Iron Ore."

Professor E. N. Horsford read a communication on "The Columnar Structure of Ice."

Dr. Charles Pickering continued his remarks, made at a previous meeting, on the forming of the earth's crust as witnessed in a congealing lava-lake within the great crater on Hawaii: —

On the floor of this and of the terminal crater of Mauna Roa (both of which on crossing he found essentially alike), *sulphur* occurs in the form of invisible fumes, impeding respiration, and in little heaps of comminuted dry powder; while above, around the brink, the sulphur comes through steam-vents forming regular "fumaroles," and is all beautifully crystallized; water in the one instance being accessible, in the other not.

Might not the similar little heaps of dry, white, tasteless powder on the floor of these craters have become some familiar mineral, could they have obtained water of crystallization?

The only crystalline mineral he could discover in the Hawaiian lavas was *chrysolite*, pea-like, and, though nowhere abundant, universally diffused; in some instances attached to a thread of the capillary obsidian, and therefore already formed when it reached the atmosphere; more frequently embedded in solid lava, a foot, perhaps, from atmospheric contact. Chrysolite occurs also in the neighboring Mauna Kea conglomerate, but in little patches, and not in detached crystals; and especially deserves attention from its presence in meteorites recently announced, presenting unexpected analogy with the internal constituents of our own planet.

When the accumulation of liquid lava becomes so great that the walls of the crater give way, a portion is sometimes squeezed through cracks a thousand feet upward upon the very brink. From the great crater the escaping lava splits the rock before it on its way down to the sea, in some instances leaving behind a squeezed-up portion here and there upon its track.

In the eruption a few months before his visit, the lava, after thirty miles' progress in the above-described manner, coming out upon the surface, poured into the sea. The consequence was a sand-storm, unapproachable for some days. When this cleared up, the new lava was found to have encroached upon the sea, and on one side there was a sand beach half a mile long, — to the ordinary observer not differing from other sea beaches; but the mineralogist would note intermingled pea-like grains of chrysolite. These seemed more abundant than elsewhere, owing, perhaps, to greater coarseness under the winnowing; just such beaches are found encircling Tahiti, where there is no active volcano.

The great crater sometimes has silent eruptions; the lava, after accumulating to the required limit, drains off and disappears; and a vessel arriving will perhaps report having passed through quantities of dead fish floating. The escaping lava continues splitting its way under the sea, and the question arises, Does it eventually manufacture granite or other crystalline rock at the bottom of the sea? The elements are all present, as appears from Dr. C. T. Jackson's published analyses of the Hawaiian lavas, — the silica, alumina, sodium, — and in about the proper proportions.

In considering the intricate limited area of crystalline rock, abutting often on deep-sea fossils in sedimentary rock, and such fossils occurring on the crest and amid the snow of the Andes, we shall have to conclude that every foot of what is now land was once the bottom of the ocean. On the other hand, a portion of what is now the bottom of the ocean was once land, as appears from coal-beds in Rhode Island and elsewhere extending underneath the sea-margin.

Professor H. P. Bowditch made a communication on "The Lymph Spaces in Fasciæ, with a new Method of Injection."

The lymph spaces existing between the tendinous fibres of fasciæ, and the connection of these spaces with lymphatic vessels, have been well described and figured by Ludwig and Schweigger-Seidel in their monograph on this subject.*

The researches of Dr. Genersich † have shown that the fasciæ, in virtue of this structure, play a very important part in keeping up the flow of lymph through the lymphatic vessels. His first experiment was as follows: A piece of fascia was removed from the leg of a dog, and tied over the mouth of a small glass funnel with the inner side (i. e. the side next to the muscles) uppermost. A few drops of a turpentine solution, the extract of alcanna root, were then placed upon this surface, and the fascia alternately stretched and relaxed by partially exhausting the air from the funnel and letting it return again. In this way the coloring matter was made to penetrate into the spaces between the fibres of the fascia, and to enter the lymph vessels on the opposite side. The same result was obtained when the coloring matter was injected between the muscle and the fascia, and the latter stretched and relaxed by passive movements of the limb. Experiments on animals where the flow of lymph through the thoracic duct was measured, showed that passive movements of the limbs increased this flow in a very striking manner. Galvanization of the muscles had a similar but less powerful effect.

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* Die Lymphgefässe der Fascien und Schuen. Leipzig. 1872.

† Arbeiten aus der physiologischen Aushalt zu Leipzig. V Jahrgang, p. 53.

The alternate widening and narrowing of the lymph spaces between the tendinous fibres seems therefore to cause the absorption of the lymph from the neighboring parts as well as its onward flow into the lymph vessels, the valves in these latter preventing, of course, a flow in the opposite direction.

In this function of the fasciæ we may perhaps find an explanation of the success of the Swedish movement-cure and of all methods of treatment which involve passive movements of the limbs, the removal of effete matters from the tissues being favored by an increased flow of lymph.

The turpentine solution of alcannine has several advantages for the injection of lymph spaces. Since turpentine does not mix with water, there is no possibility of the coloring matter being diffused by imbibition through the tissues, and thus obscuring the anatomical relations of the parts. The same immiscibility prevents also all swelling or shrinking of the tissues as a consequence of the injection. This is always to be feared when watery or alcoholic fluids are used.

A very good method of injecting the lymph spaces is as follows: Let a piece of fascia, carefully freed from loose connective tissue, be stretched somewhat tightly over the neck of a bottle. The point of a hypodermic syringe filled with the turpentine solution must be then passed obliquely into the fascia, care being taken that the point does not penetrate entirely through. If the fluid is then forced from the syringe, it will pass for a short distance into the lymph spaces, but a large portion of it will form a sort of an extravasation in the neighborhood of the point of injection. Several such partial injections may be made near the border of the piece of fascia, which must then be allowed to dry, still stretched upon the neck of the bottle. In drying, the tendinous fibres seem to shrink together, causing a dilatation of the spaces between them, in consequence of which the extravasated fluid is sucked onwards into the finest lymph spaces. In this way two, three, or even four layers of lymph spaces lying between as many different layers of tendinous fibres may be clearly demonstrated. The dried fascia may be mounted in Canada balsam between glass plates. The accompanying drawing by Dr. Quincy represents the appearance of the fascia under a low magnifying power.

Mr. E. N. Horsford read the following paper upon the Cause of the Columnar Structure of Decaying Ice: —

It is a familiar fact that ice on lakes and rivers frequently assumes, in melting, a peculiar honeycomb structure. It has been more especially remarked in the spring, by persons whose residences or pursuits have brought them in contact with the phenomena of the sudden disappearance of ice that but a short time before was thick and apparently sound.* When blocks of solid ice have been thrown on the shore of a lake or river, they more strikingly exhibit, after a few days of sunshine and a temperature above that of freezing, a structure in which the whole mass of ice seems resolved into closely set groups of irregular prisms, in the main perpendicular to the original horizontal surface.

This mass frequently retains for a long time its nearly full dimensions, while steadily lessening in weight, from the solution of the walls of what may be called the inter-columnar spaces, until at last the cohesion between the columns is overcome by gravity or slight agitation, and what remains falls to pieces, a pile of long, slender, angular rods. The diameter of these rods or irregular prisms is sometimes more than an inch, and it is sometimes less than that of a knitting-needle.

The same change frequently takes place in ice afloat, and when far advanced the ice columns may be thrust down by the foot, leaving a sharp, vertical wall around the space through which the foot has passed.

It has also been observed that where straw or litter has been dis-

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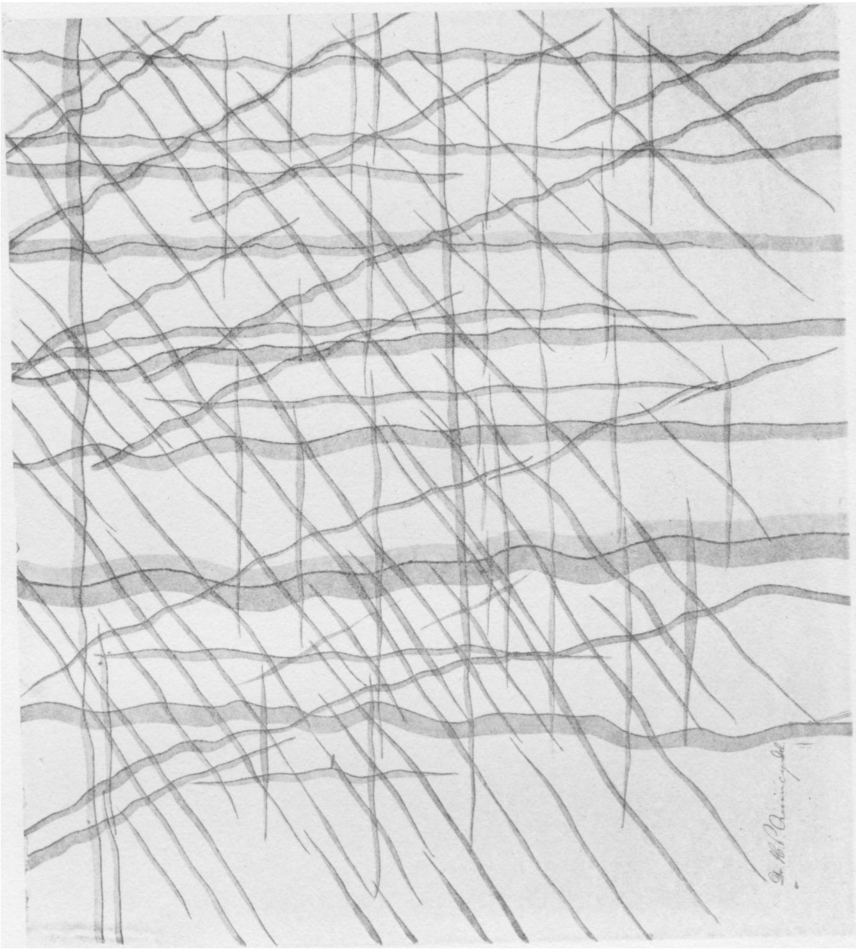
* Rev. Zadock Thompson, "Silliman's Journal," Vol. XII. 2d Series, 1851, p. 23. General Totten, chief of the engineers of the United States Army, Amer. Assoc. Adv. Science, Report for 1851. "Silliman's Journal," 2d Series, Vol. XXVIII. p. 359.



Dr. W. Nunney del.

tributed upon the ice, as in the case of a roadway across a stream or pond, the transit may be safe along the beaten track long after horses and vehicles would sink on either side. The ice in the latter case had been sheltered from the sun.

Areas of ice swept of a light fall of snow will become soft at times when neighboring ice, protected by the snow, will retain its glare and hardness. The significance of the fact of exposure to the sun's rays will presently appear.

Some sixteen years ago I began the study of this problem by taking a series of photographs of the vertical surfaces of blocks of ice, transparent and apparently thoroughly solid, or nearly so, throughout, as they slowly melted under the direct rays of the sun. These photographs, successively taken at intervals of about half an hour, showed a constant approach to columnar structure.

I exposed water to be frozen in vessels of various shapes, and photographed the ice obtained, and found the columnar structure in general perpendicular to the outer surface of the ice. When the surface was convex below, the columns curved upward toward the centre of the mass.

While pursuing this mode of investigation, I conceived the idea of taking plaster casts of the decaying ice. By placing the blocks of honeycombed ice in boxes and pouring liquid plaster, such as is used by stucco-workers, over the ice, the plaster flowed in to take the place the melted ice had left, and "*set.*" In a few hours the enclosed ice melted, and the water flowed out or escaped by evaporation. On permitting the cast carefully to dry, which was facilitated by removing the upper crust of plaster and exposing the interior to the air, and then touching the slender rods of plaster with a camel's-hair pencil dipped in a weak solution of gum-arabic, and repeating this process for several times with alternate drying, the whole cast at length acquired such consistency as to admit of being moved about with safety. The forms which were thus obtained from ice in various stages of decay, from large open ponds and from pools, were of great beauty and full of material for study.

I desire chiefly in this note to present what I conceive to be the solution of the problem of this columnar structure, that others who may perhaps have better opportunities than myself may apply the explanation and test it.

When water, by cooling at the surface, has throughout obtained its greatest density, the circulation from above downward, and the reverse, ceases. This takes place at a temperature of some 39.2 degrees Fahr. Thenceforward further reduction of temperature causes the water to congeal and expand at the surface. As still further reduction of temperature at the surface goes on, the thickness of the ice increases from below, and with this cooling comes a contraction of the superior portions of the ice. This contraction, like that of lava shrinking from loss of heat, or like that of large blocks of moist starch shrinking from loss of water, is accompanied by separation of the mass into slender columns by thin blades of space. In the case of ice, thin blades extend from above downward, and divide the ice into a kind of cellular structure. This structure in the ice, though actual, may be inappreciable to the eye, except in cases where the cells are sufficiently pronounced to become visible through the filaments or blades of air which fill the spaces left by the shrinking ice. The cracks, by which I mean the visible openings in the ice, which are readily commensurable, being frequently a considerable fraction of an inch across, I have observed in many, perhaps in most instances, are not readily traced to the bottom of the ice, but are wedge-shaped and broadest at the top. This is not invariable, however. Under some conditions I have seen the opposite sides of the cracks displaced, and the whole neighboring surface, stretching away from the crack, slightly curved downward, while the walls of the crack are lifted. This conformation would naturally follow the reduction of temperature and shrinking from above. At the bottom the ice must of course remain at 32°. In areas of ice which have been thus subjected to contraction producing visible cracks, the openings fill with water from below, which freezes, and marks by its somewhat contrasted clearness the site of the cracks. I have noticed in these cracks a peculiar transverse columnar structure, the explanation of which does not seem difficult, as will presently appear.

When, to a period of low temperature, and the production of cracks and their filling with water and freezing, there succeeds a period of warm weather, the whole body of the ice expands. Now, under the pressure consequent on this expansion, if the temperature rises to 32°, the space of the cracks filled with water must be provided for; and as the only relief for this is by increasing the thickness of the ice, or, in other words, in an elongation of the rods of ice in the honeycomb frame, there must be produced a slight vertical molecular movement which still further individualizes the columns. Thus contraction and expansion are in the course of the winter repeated with every cycle of temperature going above and below freezing, until when exposed to the higher sun of spring, or even the direct sun during the winter, especially in the case of a detached block, the surfaces of the honeycomb structure are separated from each other by the solution of the contiguous walls of ice.

The production of transverse horizontal columnar structure in the ice of the cracks above referred to is a direct result of the freezing of the water in the crack, first at the surface of contact with ice of a temperature below the freezing point.

A like columnar structure I have observed when water in bottles was frozen, as already alluded to, by exposure out of doors on very cold nights. The ice from the surface in contact with the glass is, in such cases, frequently filamentous, as if slender visible tubes converged in a general way toward the vertical axis of the bottle. Strictly speaking, the direction of the filaments is uniformly approaching a perpendicular to the surface of the bottle, whatever its conformation.

These slender white threads I have proved to be primarily, not air-tubes, but empty spaces, though when the ends of the tubes are exposed by fracture, they, of course, instantly fill with air.

As a proof that these are empty spaces, I may mention that I exposed a quantity of water in a cylindrical cast-iron vessel with rounded bottom of some half-gallon capacity to a freezing temperature in which the whole water became solid. On examining the transparent block, I noticed near the centre of the upper surface what seemed a large air-bubble shut in below a layer of ice about an eighth of an inch in thickness at the thinnest part. Around the margin of this air-bubble I raised a little wall of wax, and filled the space within the wall with colored water. With a needle I then drilled through the film of ice to the space below, when, on withdrawing the needle, the fluid passed with a rush to the before vacant cavity, filling it completely without escape of bubbles.

This vacuum had been produced by the shrinking of the main body of the ice, due to the cold after the formation of the exterior crust encasing the largest volume of the ice, the shrinking of the ice taking place while there was still a portion of water not solidified. The space left by the shrinking, filling with the remaining water, left a vacuum.

Like cavities I have produced in bottles filled with water and exposed to low temperature. The phenomenon is the same as that observed in the cooling of large cylindrical iron castings. From such cavities I have plucked out detached octahedral skeleton crystals of iron.

The phenomena of ice structure vary so greatly with the circumstances under which congelation takes place, that they seem almost infinite. Large areas of ice seem to me under certain conditions to be produced in considerable degree from what might be regarded as a snow-storm from below — the whole body of ice seeming to be made up of snow-flakes — of marvellous beauty. I have seen a snow-flake in the interior of a block of ice not less than two inches in horizontal diameter, and perfect in all its parts.

Tyndall figures a block full of these snow-flakes revealed by directing a concentrated sunbeam successively on different points in the interior of a block. In others I have found numerous fern-leaf crystals (segments of the great snow-flake) in vertical position, and several of my casts of decaying ice show the pseudomorphs of fern leaves which have dissolved out therefrom.

I have found in little cavities, commonly known as air-holes, the under surface of the thin film of ice roofing over the air space and its floor below, minute six-sided tabular crystals of dimensions great enough to be readily recognized with the unaided eye.

It is not the purpose of this note to embrace a detailed account of the observations I have made upon the phenomena of ice, but is mainly, as I have said, to present the conception I entertain of the cause of the columnar structure of decaying ice.

I conceive it to be due primarily to the alternate expansion and contraction of the ice, consequent upon cycles of temperature, resulting first in minute fissures from the shrinking, induced by cold, which, filling with air, yield a sort of honeycomb structure; and, secondarily, to the cellular structure produced by the intersection of vertical or nearly vertical blades of ice crystals, which protruded from the continuous ice above into the water below, as the thickness of the ice increased, and which vertical blades determined the surfaces where the sun's rays at the time of reflection are resolved into dark heat; and, thirdly, the elongation of the columns enclosed by the honeycomb structure consequent on the pressure caused by expansion.

The second phenomenon is like that afforded by subjecting blocks of wax to pressure. The aggregations of imperfect crystals in the case of wax are flattened out, the surface planes or planes of separation of the crystals being preserved and extended under the pressure. In ice this preservation of surface may be aided by the thin film of air which occupies the minute fissures occasioned by the shrinking of the ice. This may perhaps influence regelation, and serve to keep the columns thus honeycombed from amalgamating.

The rays of the sun falling upon and penetrating this ice are at each interior surface more or less arrested and converted into dark heat, like the heat received from the sun by the earth, and returned to the air in contact with and near the surface, and convert the ice along the planes of separation to water.

The repetition of this process at length so far separates the columns from each other that a slight strain disengages them, and the columns fall asunder, if in water to rapidly disappear in solution.*

Six hundred and fifty-fifth Meeting.

March 11, 1873. — ADJOURNED STATED MEETING.

The PRESIDENT in the chair.

The President announced the death of Hon. James Savage, a Resident Fellow; also that of Professor John Torrey, of New York, an Associate Fellow.

The verbal changes in Chapter IX., Section 3, of the Statutes, having for their object to make it conform as nearly as possible to Section 2, as amended, were referred to the President and Recording Secretary.

A paper on the "General Equation," by G. W. Pierce, was referred to the Recording Secretary.

Professor H. P. Bowditch moved that a committee of five be appointed to consider the propriety of seeking to obtain legislation providing better methods of procuring expert testimony in

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* General Totten, in the paper above referred to, suggests that the columnar structure is determined in the original formation of the ice by vertical prisms shot down from above, which increase by lateral accretion till they drive all the air in solution in the water into thin vertical films, marking the boundaries of the crystals. This suggestion may be entitled to higher consideration than my observations lead me to attach to it. It does not seem at all to meet the case of ice made up of snowflakes. The cavities or threads or filaments in ice are, moreover, as I have demonstrated, *vacua*, and not spaces filled with air.